



US009294731B2

(12) **United States Patent**  
**Morrissey et al.**

(10) **Patent No.:** **US 9,294,731 B2**  
(45) **Date of Patent:** **Mar. 22, 2016**

(54) **DYNAMIC VOD CHANNEL ALLOCATION  
BASED ON VIEWER DEMAND**

**21/47202** (2013.01); **H04N 21/6405** (2013.01);  
**H04N 21/8456** (2013.01)

(71) Applicant: **CenturyLink Intellectual Property  
LLC, Denver, CO (US)**

(58) **Field of Classification Search**  
USPC ..... 725/86-104  
See application file for complete search history.

(72) Inventors: **Michael P. Morrissey**, Overland Park,  
KS (US); **Jade D. Kerr**, Kansas City,  
MO (US); **Clinton J. Smoyer**, Raymore,  
MO (US); **Andrew V. Cook**, Lenexa, KS  
(US); **Kevin Michael McBride**,  
Gardner, KS (US)

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,357,276	A	10/1994	Banker et al.
5,453,779	A	9/1995	Dan et al.
5,461,415	A	10/1995	Wolf et al.
5,477,263	A	12/1995	O'Callaghan et al.
5,629,732	A	5/1997	Moskowitz et al.
6,018,359	A	1/2000	Kermode et al.

(Continued)

(73) Assignee: **CenturyLink Intellectual Property  
LLC, Denver, CO (US)**

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 204 days.

**OTHER PUBLICATIONS**

U.S. Appl. No. 12/487,163; Restriction Requirement dated Oct. 20,  
2011; 6 pages.

(21) Appl. No.: **13/669,982**

(Continued)

(22) Filed: **Nov. 6, 2012**

(65) **Prior Publication Data**

US 2013/0067522 A1 Mar. 14, 2013

*Primary Examiner* — Nicholas Corbo

*Assistant Examiner* — Michael Telan

(74) *Attorney, Agent, or Firm* — Swanson & Bratschun,  
L.L.C.

**Related U.S. Application Data**

(63) Continuation of application No. 12/478,404, filed on  
Jun. 4, 2009, now Pat. No. 8,332,899.

(51) **Int. Cl.**

**H04N 7/173** (2011.01)

**H04N 7/16** (2011.01)

**H04N 21/262** (2011.01)

**H04N 21/433** (2011.01)

**H04N 21/472** (2011.01)

**H04N 21/6405** (2011.01)

**H04N 21/845** (2011.01)

(52) **U.S. Cl.**

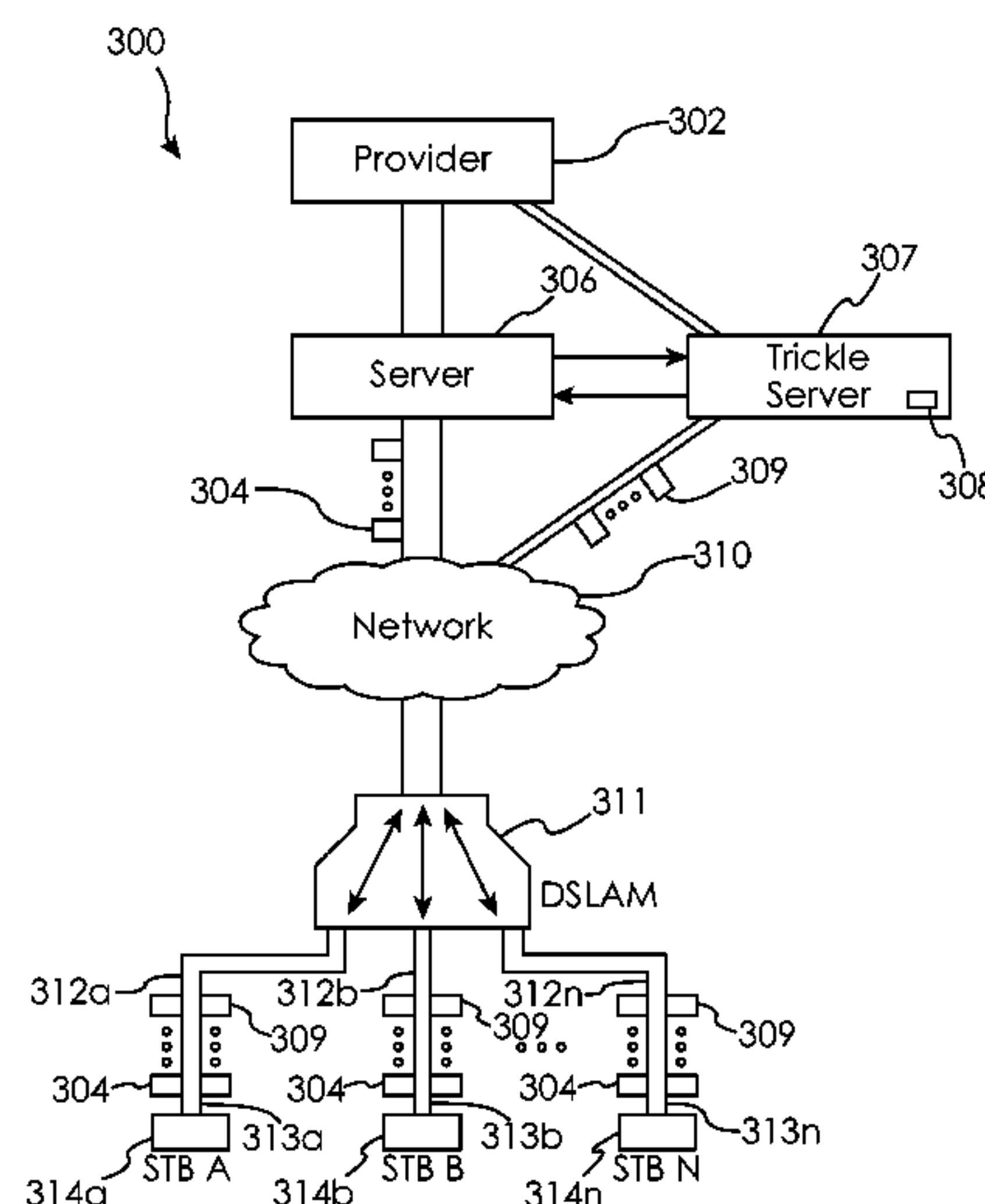
CPC ..... **H04N 7/17318** (2013.01); **H04N 21/26275**  
(2013.01); **H04N 21/4334** (2013.01); **H04N**

(57)

**ABSTRACT**

A system and method for delivering video content over a network in communication with a subscriber having an associated electronic device is disclosed. A network server is provided and is configured to transmit a plurality of multicast streams of video content over the network. A scheduled start time for the transmission of a first stream of the multicast streams is assigned. A request for the video content is received at a first time, which is after said scheduled start time and the request is the first request for the video content received by the network server after the scheduled start time. The first stream is transmitted over the network only after the request.

**20 Claims, 10 Drawing Sheets**



(56)

References Cited

U.S. PATENT DOCUMENTS

6,543,053	B1	4/2003	Li et al.
7,080,400	B1	7/2006	Navar
7,107,606	B2	9/2006	Lee
7,680,993	B2	3/2010	Dougall
7,919,979	B1	4/2011	Mason et al.
8,332,899	B2	12/2012	Morrissey et al.
2002/0095510	A1	7/2002	Sie et al.
2005/0022242	A1	1/2005	Rosetti et al.
2005/0055718	A1	3/2005	Stone
2007/0032975	A1	2/2007	Mori et al.
2007/0067484	A1	3/2007	Cheung et al.
2007/0074258	A1	3/2007	Wood et al.
2007/0162502	A1	7/2007	Thomas et al.
2007/0277205	A1	11/2007	Grannan
2008/0046584	A1	2/2008	Tucker
2008/0209062	A1	8/2008	Barrett
2008/0288991	A1	11/2008	Smoyer et al.
2008/0307453	A1	12/2008	Haberman
2009/0193486	A1	7/2009	Patel et al.
2010/0313228	A1	12/2010	Morrissey et al.

OTHER PUBLICATIONS

U.S. Appl. No. 12/487,163; Non Final Office Action dated Jan. 24, 2012; 19 pages.

U.S. Appl. No. 12/478,404; Final Office Action dated Jan. 12, 2012; 10 pages.

U.S. Appl. No. 12/478,354; Non-Final Rejection dated Apr. 27, 2012; 22 pages.

U.S. Appl. No. 12/487,163; Final Rejection dated May 31, 2012; 26 pages.

U.S. Appl. No. 12/478,404; Notice of Allowance dated Aug. 14, 2012; 17 pages.

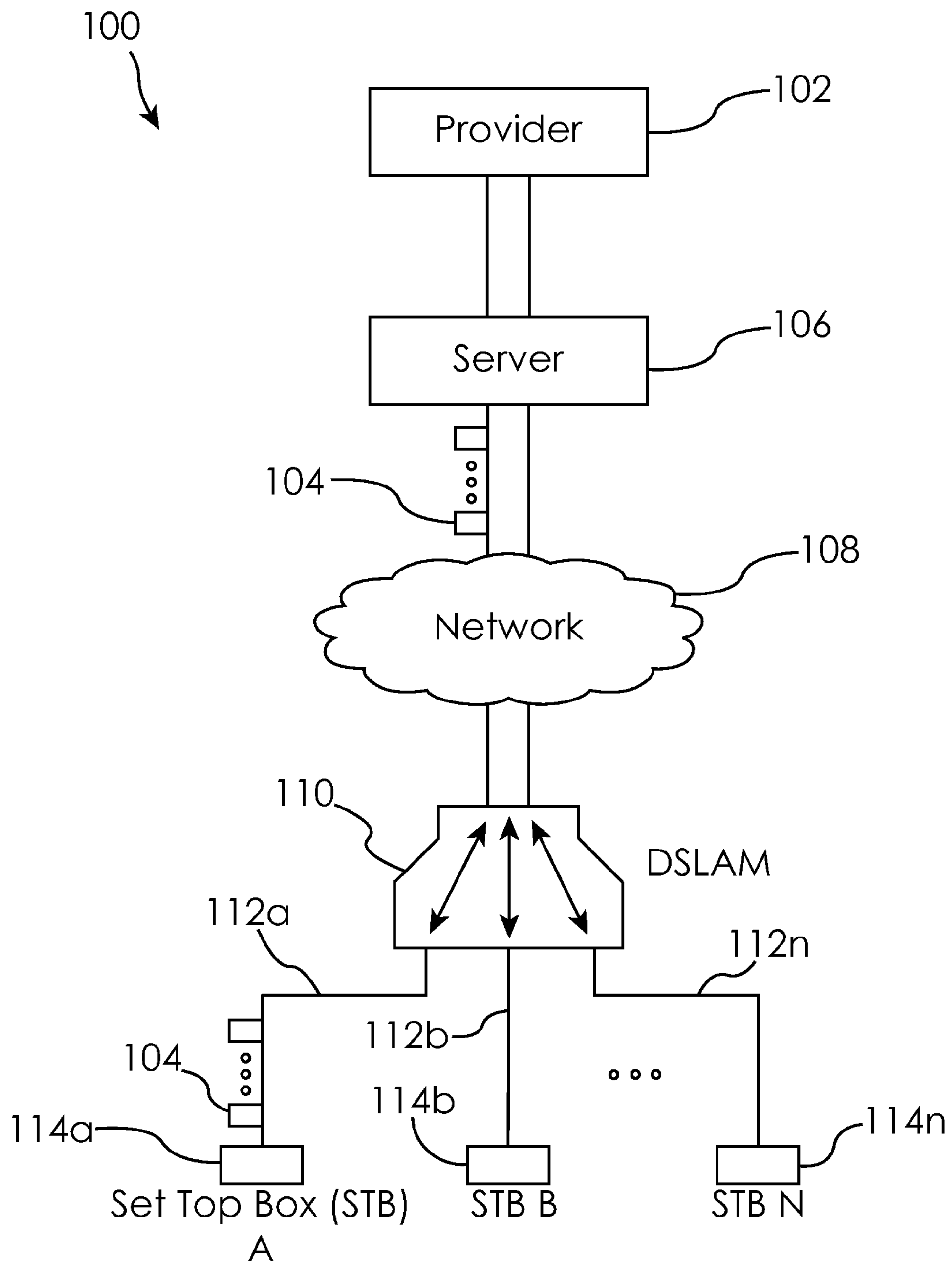
U.S. Appl. No. 12/478,404; Issue Notification dated Nov. 21, 2012; 1 page.

U.S. Appl. No. 12/478,404; Non-Final Rejection dated Jul. 7, 2011; 12 pages.

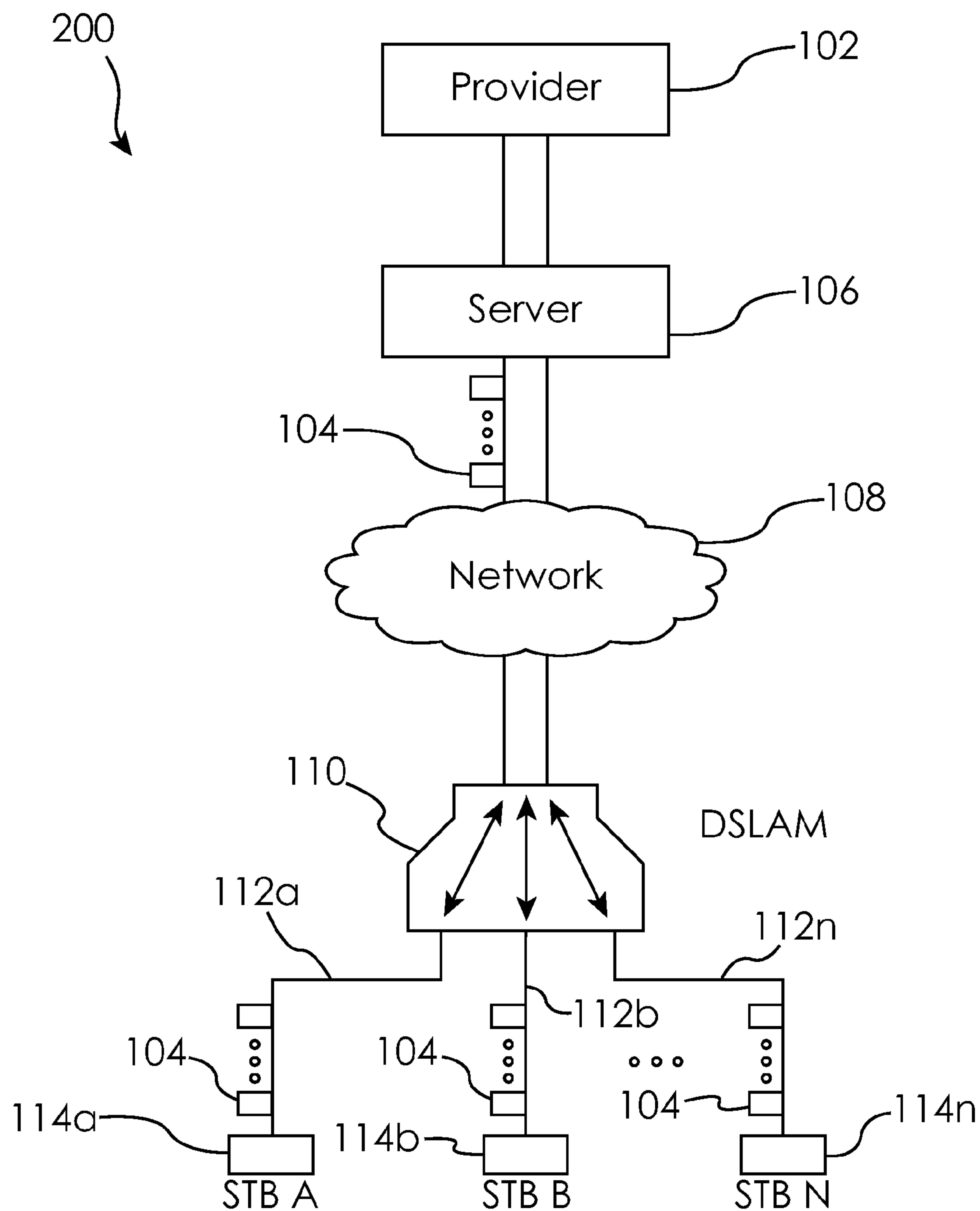
U.S. Appl. No. 12/478,404; Notice of Panel Decision dated Apr. 20, 2012; 3 pages.

Video on Demand, [http://en.wikipedia.org/wiki/Video\\_on\\_demand](http://en.wikipedia.org/wiki/Video_on_demand); Jan. 8, 2009; 5 pages.

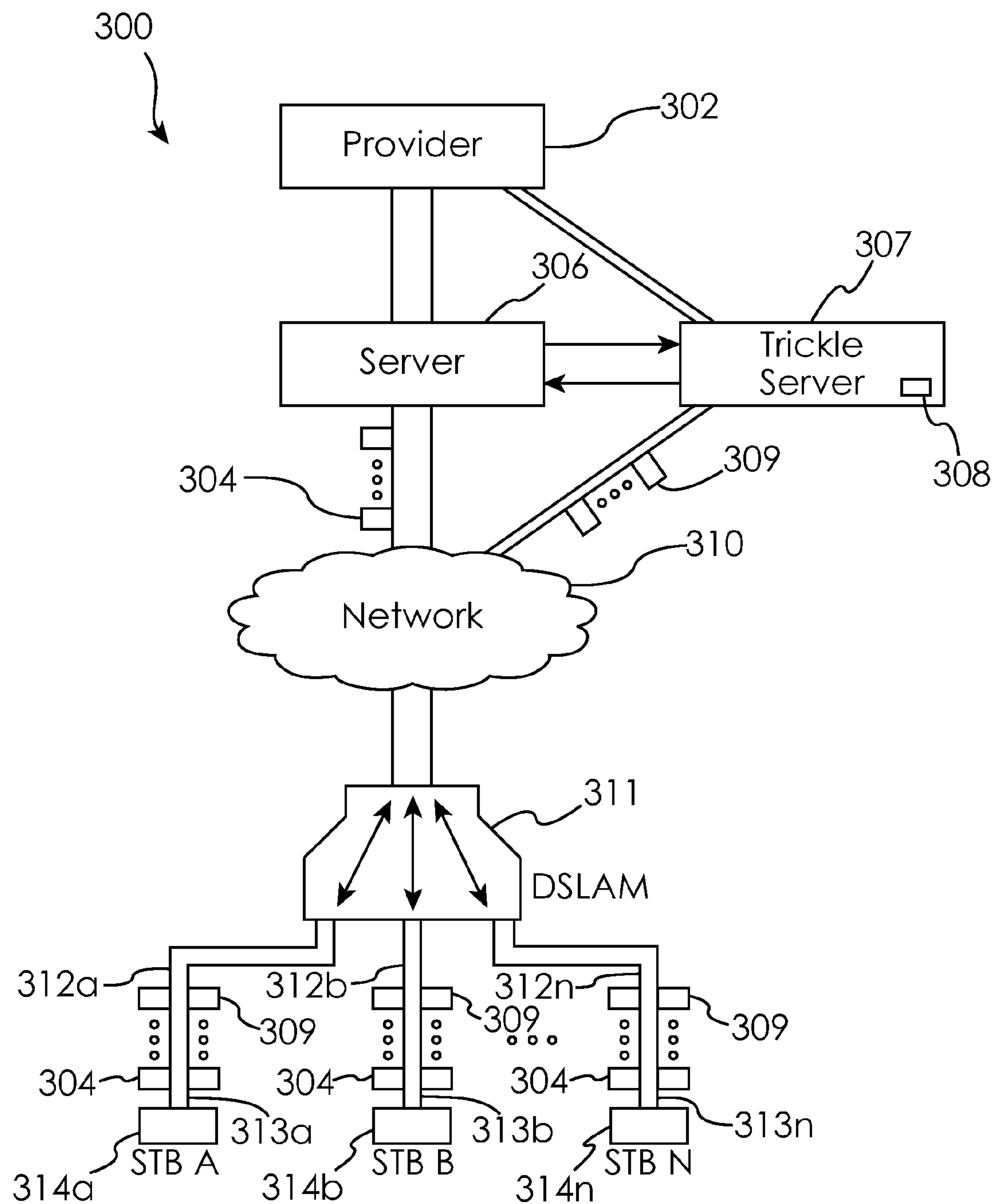
Oz, Ran, "Switched Unicast: It's Not Just About Capacity", BigBand Networks, pp. 1-11.

**Fig. 1**

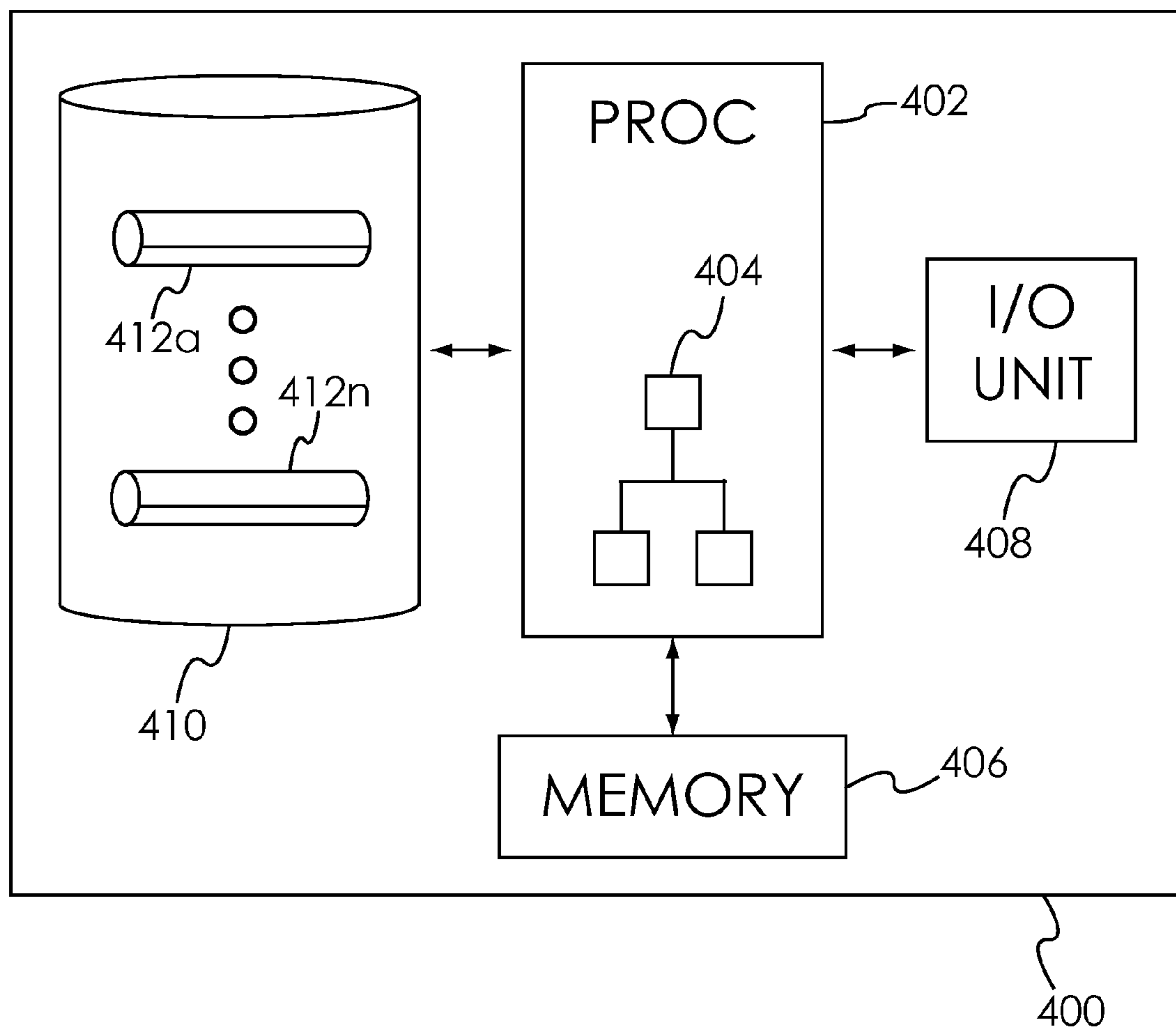
(Prior Art)



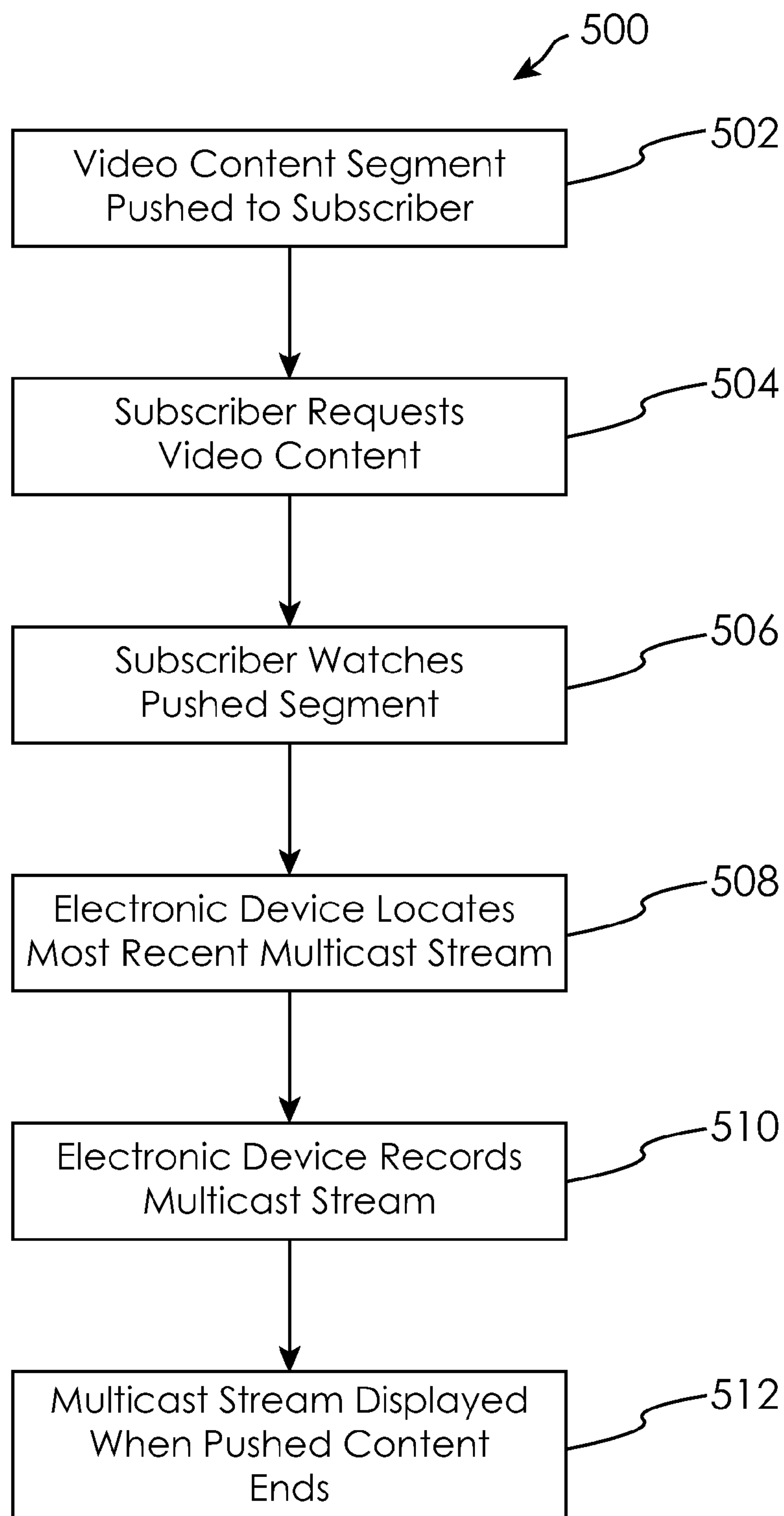
**Fig. 2**  
(Prior Art)

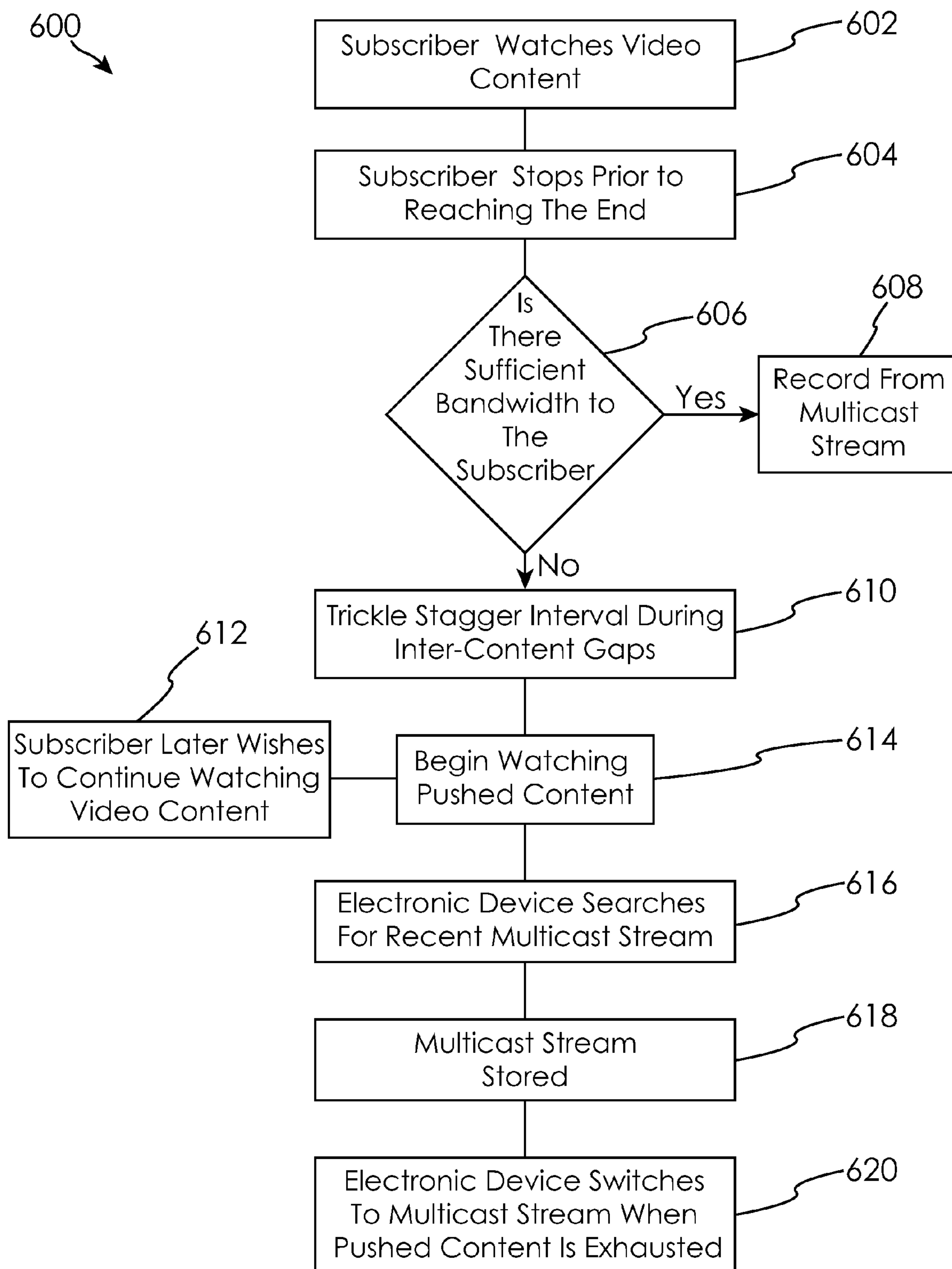


**Fig. 3**

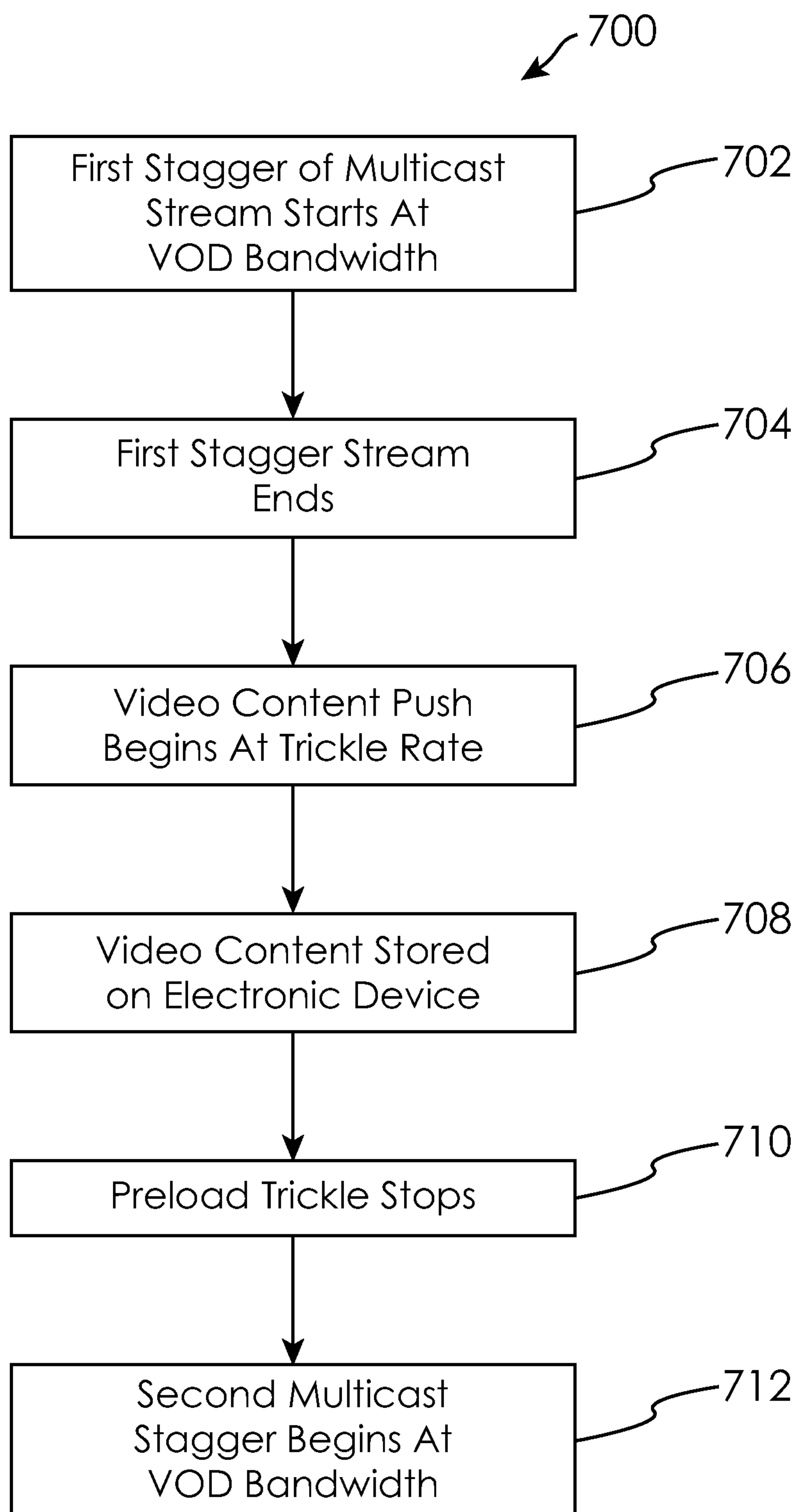
**Fig. 4**



**Fig. 5**

**Fig. 6**



**Fig. 7**

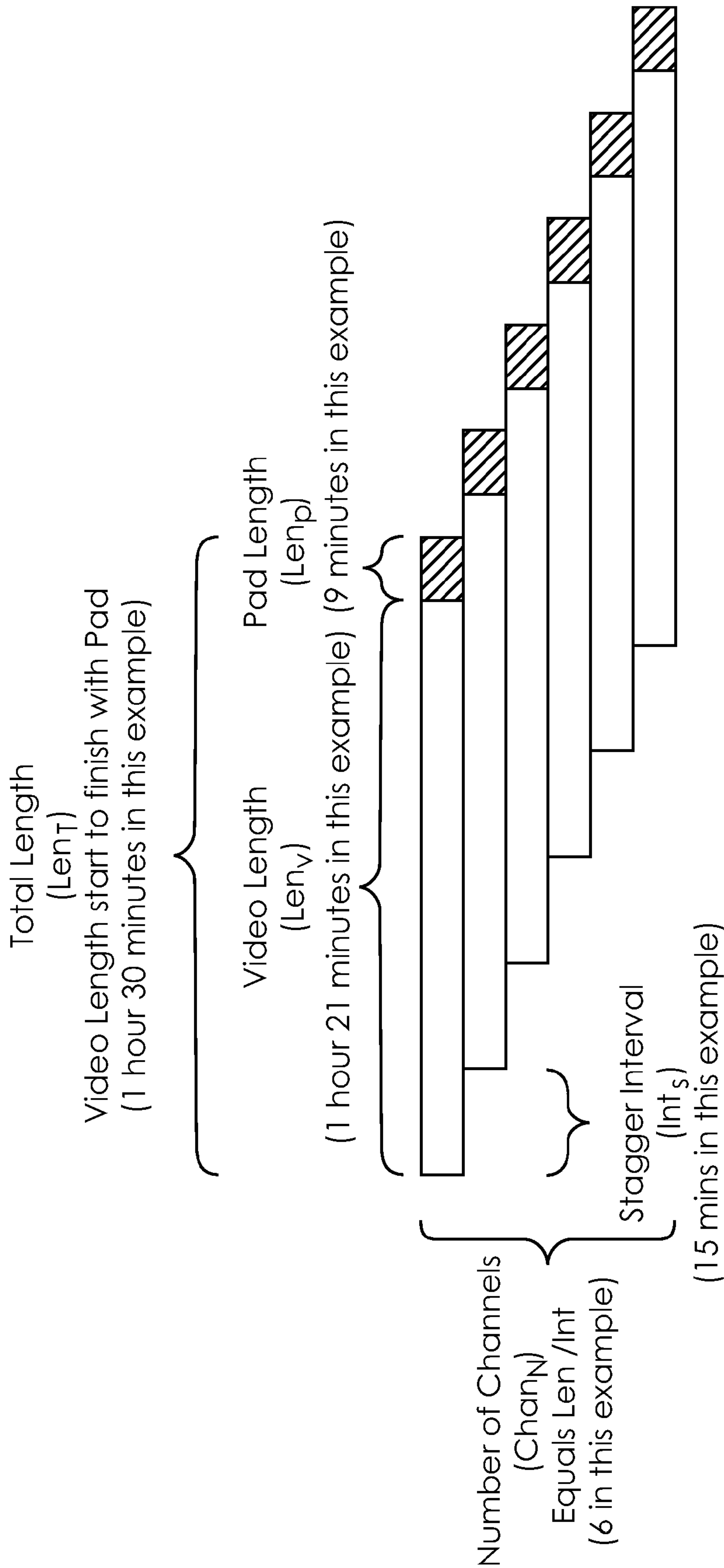
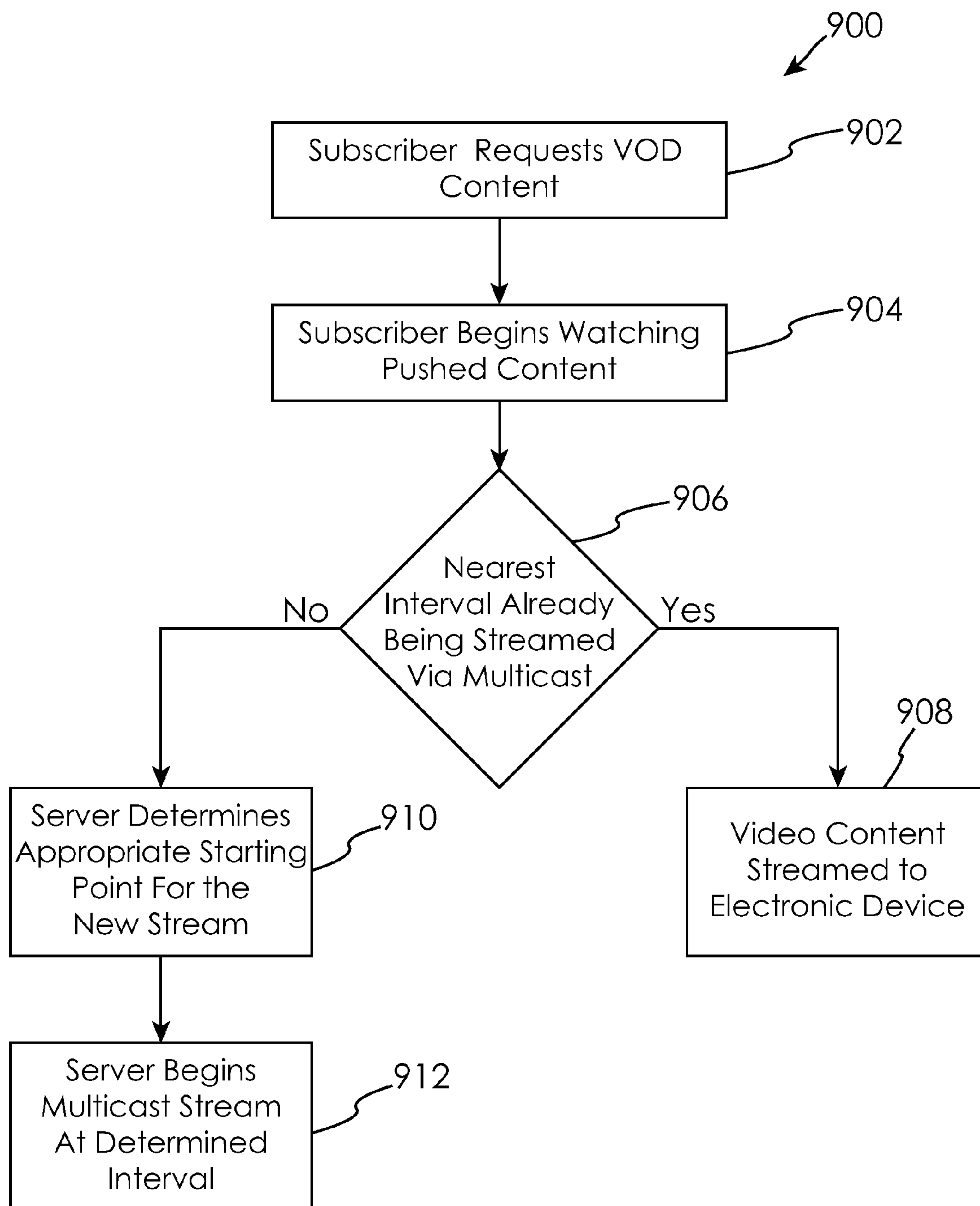
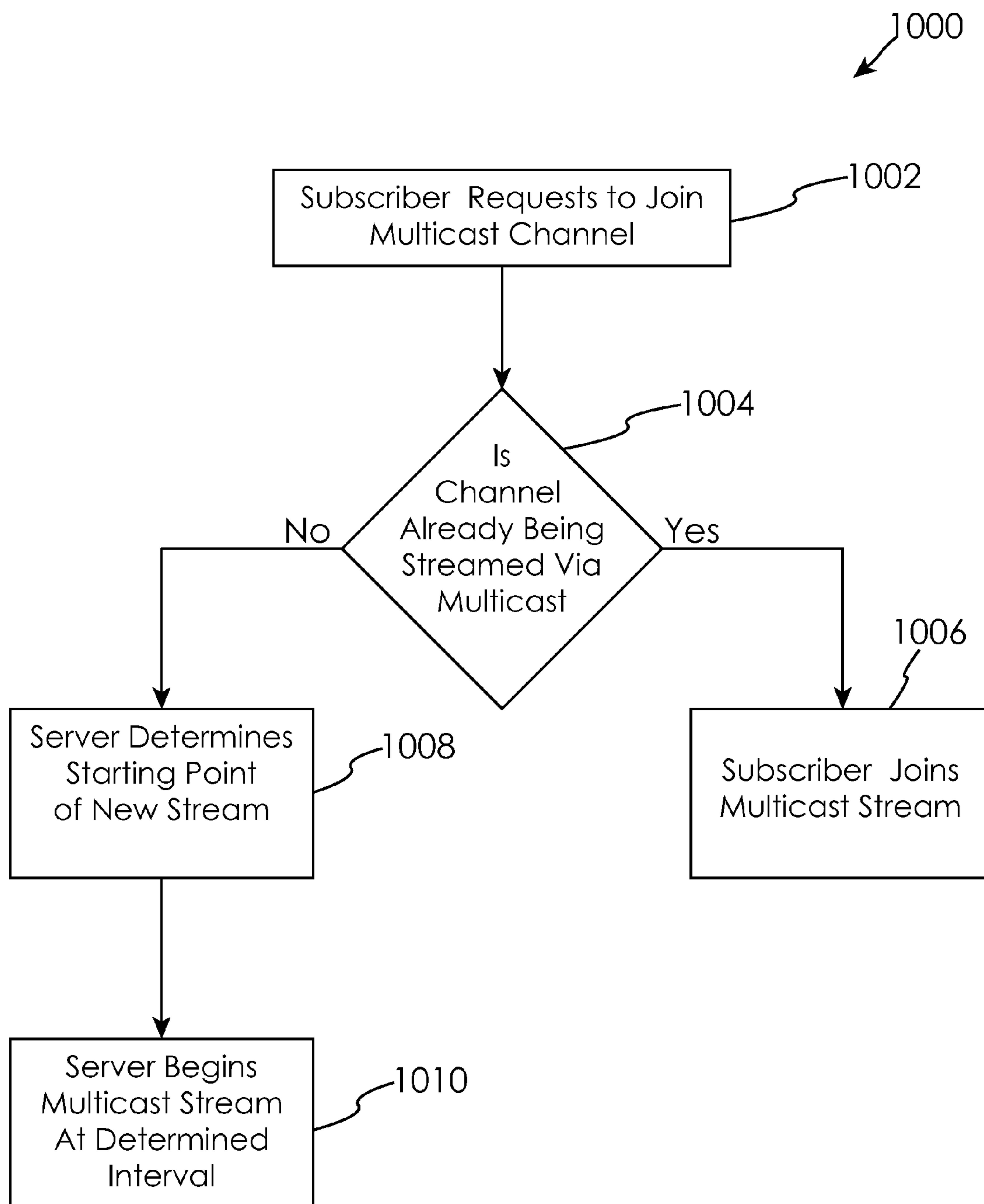


Fig. 8

**Fig. 9**

**Fig. 10**



## DYNAMIC VOD CHANNEL ALLOCATION BASED ON VIEWER DEMAND

### CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 12/478,404, filed Jun. 4, 2009 by Michael P. Morrissey et al. and entitled, "Dynamic VOD Channel Allocation Based on Viewer Demand", which is hereby incorporated by reference in its entirety.

### BACKGROUND

As technology has developed, so have the ways in which viewers obtain video content. Not long ago, viewers could either watch video broadcast to their television sets or by traveling to the local cinema to watch a motion picture. VHS tapes and DVDs eventually emerged, both of which allowed viewers to watch the video content whenever they chose.

With the development of Internet protocol television (IPTV), communication companies are establishing networks for subscribers to watch video content. Generally, IPTV describes a system where a digital television service is delivered using Internet protocol (IP) over a network. The network used for IPTV may include the public Internet or a private IP network controlled by an IPTV service provider via a broadband connection known as digital subscriber lines (DSL), where the digital subscriber lines typically include conventional telephone lines with copper wire into households. Alternatively, the digital subscriber line may be fiber to the premises (FTTP). Telecommunication service provider companies that have begun offering DSL have limited bandwidth resources, particularly when delivering video over existing copper wire infrastructures.

In addition to television programming, many communications companies offer their subscribers video on demand (VOD) services. FIG. 1 is an illustration of a conventional system 100 that is configured to deliver VOD. As shown, a provider 102 is communicatively connected to a head-end server 106. Server 106 is used to store video content delivered to it from service provider 102. The server 106 is also capable of delivering video content 104 over a network 108, such as the internet or public/private packet switched network (PSN), for example. As shown, server 106 is configured to transmit video content in the form of data packets 104. The server 106 delivers the video content 104 via the network 108 to a DSL access multiplexer (DSLAM) 110. The DSLAM 110 operates to connect subscribers to the network 108, host video streams/Internet group management protocol (IGMP), and provide Ethernet transport of the video content. The DSLAM 110 further operates as a multiplexer to distribute the video content 104 through communication lines 112a-112n to set top boxes (STB) 114a-114n (collectively 114). Additionally, the DSLAM 110 may also communicate VOD requests from a particular STB 114 to the server 106 via network 108.

Today, VOD typically exists as a unicast video stream, as illustrated in FIG. 1. In a unicast stream set-up, there is one video stream for each subscriber requesting the video content. Therefore, if 100 subscribers request to receive a particular video file, 100 distinct copies of the video are delivered through the system. As shown in FIG. 1, STB A 114a initiated the request for video 104. After STB A 114a requested the video, server 106 initiated the delivery through network 108 and to STB A 114a. As shown, STBs B-N 114b-n did not receive the video. However, if STB B 114b requested the same video only moments after STB A 114a, duplicate copies

of the video content 104 would simultaneously be streamed through the network 108. As can be appreciated, delivering video through a unicast video stream can bombard systems and dramatically reduce available system bandwidth when multiple subscribers request video content.

Therefore, service providers have begun to offer video content through a multicast video stream. A multicast video stream is illustrated in FIG. 2. Multicast stream network 200 is similar in most respects to unicast system 100. However, in contrast to the unicast video stream, multicast video streams are delivered to all subscribers connected to the network. As shown in FIG. 2, video 104 is delivered to all STBs 114a-n. In some versions of multicast VOD systems, multiple copies of the same video content are streamed through the network beginning at various intervals (e.g., every 15 minutes). This allows a video service provider to limit the number of video streams for particular video content, thereby limiting the amount of bandwidth dedicated to that video. However, multicast streaming requires the subscribers interested in the video content to begin watching the video content at a set time or at set intervals, which undermines the "on demand" aspect of VOD. Further, a substantial amount of bandwidth is still consumed by typical multicast VOD systems.

Additionally, electronic devices exist on the market that allow users to record video content based on the user's selection criteria. Digital video recorders (DVRs) allow consumers to record digital video content, such as video 104. Some service providers provide as an option to their subscribers the opportunity to lease a DVR from the provider, as opposed to the subscribers purchasing their own.

In light of the above, there exists a need for a system that provides true VOD while minimizing traffic on the network.

### SUMMARY

The present invention provides an improved VOD system and method. The claims, and only the claims, define the invention.

The principles of the present disclosure provide a system and method for dynamically allocating VOD channels based on subscriber demand. By waiting to stream certain multicast channels until a subscriber actually requests it, the service provider can potentially save large amounts of bandwidth from unnecessarily being used.

In one aspect of the present disclosure, a method for delivering video content over a network in communication with a subscriber having an associated electronic device comprises the steps of providing a network server configured to transmit a plurality of multicast streams of video content over the network and assigning a scheduled start time for the transmission of a first stream of the multicast streams. The method further comprises the steps of receiving a request for the video content at a first time, which is after said scheduled start time and the request is the first request for the video content received by the network server after the scheduled start time, and transmitting the first stream over the network only after the request.

It is an object of certain embodiments of the present disclosure is to provide an improved VOD system and method.

Further, objectives and advantages of the present invention will appear as the description proceeds.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustration of a conventional system configured to deliver VOD via a unicast stream.



## 3

FIG. 2 is an illustration of a conventional system configured to deliver VOD via a multicast stream.

FIG. 3 is an illustration of an exemplary system configured to deliver VOD in accordance with the principles of the present disclosure.

FIG. 4 is a block diagram of an exemplary device utilized to deliver video content to a subscriber.

FIG. 5 is a flow chart of an exemplary process of VOD delivery.

FIG. 6 is a flow chart of a further exemplary process of VOD delivery.

FIG. 7 is a flow chart of another exemplary process of VOD delivery.

FIG. 8 is an illustration depicting various terms and concepts discussed in the present disclosure.

FIG. 9 is a flow chart of a further exemplary process of VOD delivery.

FIG. 10 is a flow chart of yet another exemplary process of VOD delivery.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, and alterations and modifications in the illustrated device, and further applications of the principles of the invention as illustrated therein are herein contemplated as would normally occur to one skilled in the art to which the invention relates.

The language used in the claims is to only have its plain and ordinary meaning, except as may be explicitly defined herein. Such plain and ordinary meaning is inclusive of all consistent dictionary definitions from the most recently published Webster's dictionaries and Random House dictionaries.

The principles of the present disclosure provide a system and method for dynamically allocating VOD channels based on subscriber demand. By waiting to stream certain multicast channels until a subscriber actually requests it, the service provider can potentially save large amounts of bandwidth from unnecessarily being used.

FIG. 3 is an illustration of an exemplary network 300 configured to deliver VOD content to network subscribers in accordance with the principles of the present disclosure. As shown, a service provider 302 is communicatively connected to a head-end server 306, which is communicatively connected to a trickle server 307. A processor 308 is communicatively connected with trickle server 307. Server 306 and trickle server 307 are used to store video content delivered, transferred and/or uploaded to it from provider 302. Server 306 is capable of delivering video content 304 over a network 310, such as the internet or public/private packet switched network (PSN), for example. As shown, server 306 is configured to transmit video content in the form of data packets 304. The server 306 delivers the video content 304 via the network 310 to a DSL access multiplexer (DSLAM) 311. The DSLAM 311 operates to connect subscribers to the network 310, host video streams/Internet group management protocol (IGMP), and provide Ethernet transport of the video content. The DSLAM 311 further operates as a multiplexer to distribute the video 304 through communication lines 312a-312n to set top boxes (STB) 314a-314n (collectively 314). Additionally, the DSLAM 311 may also communicate VOD requests from a particular STB 314 to the server 306 via network 310.

## 4

As previously noted, network 300 includes trickle server 307 and processor 308. Trickle server 307 is capable of delivering video content 309 over the network 310. As shown, trickle server 307 is configured to transmit video content in the form of data packets 309. For the sake of clarity, video content 304 is distinguished from video content 309, though the video content of each may relate to the same video or data. However, as used herein, video content 304 represents the video content delivered from server 306 to STBs 314 via multicast streams. Video content 309 represents the video content trickled or pushed to STBs 314 as described herein. Like server 306, trickle server 307 delivers the video content 309 via the network 310 to DSLAM 311. The DSLAM 311 further operates as a multiplexer to distribute the video 309 through communication lines 313a-313n to STBs 314. As shown, communication lines 312 and 313 are shown as distinct lines from DSLAM 311 to STBs 314. In another embodiment, communication lines 312 and 313 may comprise a single data communication line. Processor 308 may be provided within trickle server 307 (as shown) or maintained separately from trickle server 307. As illustrated, trickle server 307 exists as a separate unit from server 306. Alternatively, trickle server 307 and server 306 may form or exist in a single unit.

In accordance with one embodiment of the present disclosure, server 306 distributes video content 304 via a multicast stream. For example, server 306 may stagger streams of "Movie A" in 15 minute intervals. In the known systems, such as multicast network 200, a subscriber wishing to view "Movie A" would either have to wait until the next stagger started or begin watching the most recent stream and miss some of the previously streamed content.

In order to provide the subscriber with a true VOD experience, a segment of video content 309 is slowly streamed to STBs 314 where the segment can be stored. As described above, video content 309 represents the video content, trickled or pushed to STBs 314. Server 306 may communicate with trickle server 307 and/or processor 308 to provide information related to the video content. For example, server 306 may communicate the stagger interval of "Movie A" to trickle server 307 and/or processor 308. Processor 308 may then determine the appropriate parameters of trickle delivery, such as the time required to push the appropriate segment of "Movie A", the amount of memory on STB 314 required to store the segment of "Movie A", etc.

In one embodiment of the present invention, the service provider 302 may determine to trickle or push a segment of video content 309 only for high-demand or seasonal content. If more subscribers are simultaneously watching the video content than the number of multicast streams, then bandwidth is saved on the network.

In one embodiment of the present invention, the service provider 302 determines a particular trickle rate or bandwidth to push a segment of video content onto STBs 314. The service provider 302 may determine a trickle rate applicable to all video content. Alternatively, the trickle rate may be dependent on the particular video content. The trickle rate may be determined by balancing competing interests. First, the service provider 302 may want the trickle bandwidth to be large enough to push the segment of video onto STB 314 in a reasonable amount of time. Second, the service provider 302 may not want the trickle bandwidth to be so large so as to impede the subscriber's viewing ability. In one embodiment, the trickle bandwidth is determined to be 512 Kbps.

In one embodiment, the service provider, server 306, trickle server 307 and/or processor 308 may periodically determine whether stored segment 309 has been accessed. If



## 5

the stored segment **309** has gone unused for a specific number of days or weeks, the stored segment **309** may be deleted in accordance with their content contracts. Alternatively, the service provider may allow the subscriber to determine how long the video content is maintained on the electronic device and the subscriber may then delete the video interval **309** to make more memory available for other content.

FIG. **4** is a block diagram of an exemplary system device **400** utilized to deliver video content to an end-user (e.g., subscriber). The device **400** may be generally representative of a number of systems utilized to deliver video content associated therewith to end-users. For example, the device **400** may represent a head-end server **306**, trickle server **307** and/or set top box **314**. As shown, the device **400** includes a processing unit **402**, which may be formed of one or more processors, that executes software **404**. The software, depending upon the system functionality, may be configured to store and (i) manage information, such as video content, (ii) manage routing of video streams, (iii) locate and store existing video streams and/or (iv) manage interaction with an end-user to download video programming and images for display on a television or other electronic display.

The processing unit **402** may be in communication with a memory **406**. The memory **406** may be a random access memory, flash memory, or any other memory type. The processing unit **402** may also be in communication with an input/output (I/O) unit **408** that is configured to communicate with a television or other electronic display, remote control, network, or other devices, such as digital video disc (DVD), digital video recorder (DVR), or any other local or network located device. The processing unit **402** may additionally be in communication with a storage unit **410** that is configured to store video data files in data repositories **412a-412n** (collectively **412**).

FIG. **5** is a flow chart of an exemplary process **500** of system operation for delivering VOD to subscribers. The process **500** starts at step **502**, where a video content segment is pushed and stored on an electronic device associated with the network subscribers. In one embodiment, the electronic device may be a STB. In another embodiment, the electronic device may be a DVR. In one embodiment, the length of the pushed segment of video content is dependent upon the time between the staggered streams of the multicast delivery. At step **504**, a subscriber requests to view particular video content which is related to the segment of pushed video content. According to one aspect of the present disclosure, the multicast streams delivered by server **306** are hidden from the subscribers. Therefore, the multicast streams may not appear on any program guide viewable by the subscriber.

At step **506**, the subscriber's electronic device retrieves the pushed video content interval and the subscriber begins to watch the pushed video segment. At step **508**, the electronic device locates the multicast stream that began most recently. Once located, the electronic device begins to record that multicast stream (step **510**). According to one aspect of the present disclosure, the subscriber is free to pause, rewind, fast-forward, etc. within the video content that has been received and recorded. The electronic device will continue to record the content from the located multicast stream until it reaches the end of the particular multicast stream. When the electronic device reaches the end of the pushed video content segment, the electronic device will begin to present the recorded multicast stream to the subscriber (step **512**). In one embodiment, the electronic device provides a seamless transition between the two sets of recorded data (the pushed segment and recorded multicast stream) and the subscriber is unaware that any transition takes place.

## 6

At this point, the entire video content is on the subscriber electronic device. The service provider may choose to allow the subscriber to view the video content for a specific number of days and then have the content expire in accordance with an existing content contract. Alternatively, the service provider may allow the subscriber to determine how long the video content is maintained on the electronic device.

FIG. **6** is a flow chart of a further exemplary process **600** for system operation for delivering VOD to subscribers. The process **600** begins a step **602** where a subscriber is watching particular video content. If the subscriber stops watching the particular video content prior to reaching the end of the content (step **604**), the subscriber likely has an expectation to return to the content and pick up where it was left off. To facilitate this, multiple methods may be employed. At step **606**, processor **308** of trickle server **307** determines if there is sufficient bandwidth to the subscriber. Alternatively, server **306**, trickle serve **307** or another network device may determine whether sufficient bandwidth to the subscriber exists. If there is sufficient bandwidth to the subscriber, the stream may continue to be recorded from the multicast stream by the electronic device associated with the subscriber (step **608**). In one embodiment, the remainder of the video content may then be recorded from the multicast stream. In another embodiment, only a segment or portion of the video content is recorded from the multicast stream and stored on the electronic device associated with the subscriber. The length of the recorded segment may be equal to the multicast stagger interval to allow resumption to any multicast stream in the future.

If there is a lack of bandwidth to the subscriber, such as if the subscriber has changed to different video content, a variety of methods may be employed. One option (not illustrated) is that the video content may be continued as a traditional VOD upon resumption, i.e. unicast or multicast. Alternatively, the provider may also leverage the inter-content gaps that are created (if multicast stagger intervals are selected based on integers) to trickle an additional segment of video content to the subscriber (step **610**). The length of the pushed segment may be equal to the multicast stagger interval to allow resumption to any multicast stream in the future. When the subscriber later wishes to continue watching the video content (step **612**), the subscriber will begin watching the pushed content segment (step **614**). At step **616**, the electronic device then locates the multicast stream that began most recently. Once located, the electronic device begins to record the multicast stream (step **618**). The electronic device will continue to record the content from the located multicast stream until it reaches the end of the multicast stream or the subscriber stops watching the video content. When the pushed content interval is exhausted, the electronic device will begin to present the recorded multicast stream to the subscriber (step **620**). In one embodiment, the electronic device provides a seamless transition between the two sets of recorded data and the subscriber is unaware that any transition takes place.

As described above, the service provider can use the inter-content gaps to trickle down the segment of video content. The described leveraging of inter-content gaps may be utilized independently of, and need not rely on, the methodology described above. FIG. **7** is a flow chart of another exemplary process **700** for pushing a segment of video content by leveraging inter-content gaps. The process **700** begins at step **702** where server **306** delivers the first staggered stream of a video content on a particular channel via a multicast transmission at a standard VOD bandwidth. At step **704**, the first multicast staggered stream ends. At step **706**, a segment of video content begins to be delivered from trickle server **307** at the



determined trickle rate. In one embodiment, the VOD bandwidth is larger than the trickle rate. The trickled segment of video content is then stored on the electronic devices associated with the network subscribers (step 708). Eventually, the preload trickle is stopped (step 710) to allow the second staggered stream of multicast video content to be delivered in the same channel at the standard VOD bandwidth (step 712). In one embodiment, this process is repeated until a segment of video content is trickled to the subscriber electronic devices having a length equal to the stagger interval between successive multicast streams of the same video content.

The service provider may need to be aware of the amount of bandwidth and time required to push the initial preload content to end users and the amount of local storage required. FIG. 8 illustrates the terms and concepts applicable to the present disclosure related to leveraging of inter-content gaps. As used herein, the following definitions apply.

$Len_V$  is the length of the actual video content in seconds.

$Int_S$  is the stagger interval between successive multicast streams of the same content in seconds.

$Len_R$  is the length of content pushed to the subscriber electronic device, which is equal to  $Int_S$ .

$Len_T$  is the total length of the video plus a pad length and is equal to  $(Len_V + Len_P)$ .

$Chan_N$  represents the number of channels required to stream the same content and is equal to  $(Len_T / Int_S)$ .

$Len_P$  is the buffer added to  $Len_V$  required to make  $Chan_N$  an integer.

$Rate_E$  is the encoded rate of the video content in bits per second.

$Rate_T$  is the trickle rate available to push content to the subscriber electronic device in bits per second. In one embodiment,  $Rate_T$  is slower than the rate the multicast streams of video content are delivered over the network.

$Time_P$  represents the time required to trickle video content of  $Len_R$  to the subscriber electronic device and equals  $((Rate_E / Rate_T) * Len_R)$ .

$Size_R$  represents the size of content pushed to the subscriber electronic device (8,000,000 assumes power-of-10 storage units) and equals  $(Rate_E * (Len_R / 8000000))$ .

As described above, it is contemplated that the video content may be delivered to all capable STBs via a multicast stream, by leveraging inter-content gaps, or through use of a dedicated trickle server. To determine the amount of time required to push a preload segment of video content and determine the amount of storage required, the service provider and/or processor 308 of trickle server 307 may take the encoding rate of the content in bits per second, divide that value by the available trickle rate, and then multiply the result by the prerecord length. For this example, powers of 10 are used rather than powers of 2 for Mbps/Kbps for clarity. In this example, the video is encoded at a rate of 8 Mbps and the provider has 512 Kbps available for the trickle rate. As shown in FIG. 8, the length of preload segment ( $Len_R$ ) is 15 minutes. Thus, the trickle server will need  $(8000000 / 512000) * 15$  minutes = 234.375 minutes (~3.9 hours) to push the preloaded content onto the subscribers' STBs at a trickle rate of 512 Kbps.

For storage, the push content will require an amount of memory equal to the encoding rate of the content in bits per second, multiplied by the prerecord length times 60 (to convert into seconds). The result is then divided by 8000000 to convert to MBytes (powers of 10 used again). For example, video encoded at 8 Mbps with a 900 second (15 minute) preload segment would result in required storage space of  $(8000000 * 900) / 8000000 = 900$  MBytes.

The inter-content gap ( $Len_P$ ) is utilized to allow for ease of human readability. In one embodiment, this gap can be set to zero (or extremely small) if stagger times that are non-integer or not multiples of 5 minutes are acceptable. For example, the 121 minute video content in the example could use the same 6 streams with a stagger interval of 13.5 minutes (121/6) with no padding. Though such a stagger may reduce the preload time and storage requirements, the non-integer stagger may make it difficult to present on existing scheduling infrastructure.

FIG. 9 is a flow chart of a further exemplary process 900 for system operation for dynamically delivering VOD to subscribers. The process 900 begins a step 902 where a subscriber requests particular video content. An electronic device associated with the user retrieves the pushed segment of video related to the particular video content and the subscriber begins to watch the pushed segment (step 904). At some point before the subscriber reaches the end of the pushed segment of video content, a network device determines if the nearest video interval is already being streamed (step 906). In one embodiment, the network device is the electronic device associated with the subscriber. In another embodiment, the network device is a network server. If the nearest video interval is already being streamed, the video content is streamed to the electronic device as described herein (step 908).

If the nearest interval of video content is not being streamed, the network server determines the appropriate starting point for a new multicast stream of video content (step 910). At step 912, the server then begins the multicast stream at the determined interval, which is received by the electronic device. In this embodiment, the server exhibits the ability to "stitch" in the appropriate multicast stream that the subscriber is requesting and enables the service provider the ability to dynamically allocate multicast channels. For example, if a subscriber is watching the first 15 minutes of video content that has been pushed to his/her electronic device and is nearing the end of that segment, the server needs to be aware of the impending requirement for the subscriber to join a multicast stream. Accordingly, the server needs to then begin streaming the appropriate multicast transmission at the determined interval to provide the subscriber with the video content at the correct time. To that end, the server tracks the pre-scheduled start times for all streamed content regardless of whether the streams are viewed or not.

FIG. 10 is a flow chart of exemplary process 1000 for system operation for dynamically delivering VOD to subscribers. Unlike process 900, process 1000 does not rely on video content being pushed to a subscriber electronic device. However, like process 900, process 1000 allows the service provider to dynamically allocate channels, thereby enabling the service provider to possibly save valuable network bandwidth. Process 1000 begins at step 1002 where a subscriber requests to join a multicast channel. A network device determines if the channel is already being streamed via multicast transmission (step 1004). If so, the subscriber joins the multicast stream (step 1006).

If the channel is not already being streamed, the network server determines the appropriate starting point for a new multicast stream of video content (step 1008). At step 1010, the server then begins the multicast stream at the determined interval, which the electronic device joins. In this embodiment, if the first viewer begins to watch a particular multicast stream in the middle of what would otherwise be a movie in progress, the server will begin that stream as though it had been playing all along. In one embodiment, the server tracks the pre-scheduled start times for all streamed content and starts the content "in-progress" if the first viewer joins the



stream after it had been scheduled to start. For example, a multicast stream may have a pre-scheduled start time of 8:00 pm. If a subscriber joins that stream at 8:12 pm, the server will begin streaming the video content as if the stream had actually started at 8:00 pm.

The disclosed dynamic channel allocation, processes **900** and **1000** being two examples, can save network bandwidth by reducing the number of multicast streams not being viewed by subscribers. For example, if a 120 minute movie is broken into 8 staggered multicast streams, each beginning in 15 minute intervals, those 8 channels will occupy 64 Mbps of bandwidth on the network regardless of whether 1 subscriber or 300 subscribers are watching all 8 streams. By dynamically allocating multicast channels, if only four of the 8 multicast channels are actually being viewed by subscribers, then only four streams are actually transmitted and the network bandwidth for the particular video content is effectively cut in half.

In one embodiment, the disclosed methodology is limited to those STBs leased by the provider to the subscribers. Accordingly, server **306** may verify that STBs **314** of FIG. **1** are the property of the provider **302** instead of the individual subscriber.

Although the principles of the present disclosure have been described in association with set top boxes, it should be understood that the set top box functionality may be incorporated into a television or network and use the principles of the present disclosure in the same or similar manner.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected. It is also contemplated that structures and features embodied in the present examples can be altered, rearranged, substituted, deleted, duplicated, combined, or added to each other. The articles "the", "a" and "an" are not necessarily limited to mean only one, but rather are inclusive and open ended so as to include, optionally, multiple such elements.

What is claimed is:

**1.** A method for delivering video content over a network in communication with a subscriber having an associated electronic device, the method comprising the steps of:

providing a network server configured to transmit a plurality of multicast streams of video content over the network;

assigning a scheduled start time for the transmission of a first stream of the multicast streams;

pushing a segment of the video content to the electronic device during an inter-content gap, the pushed segment of video content having a length that is less than a total length of the first stream and at least equal to and dependent upon a stagger interval between the scheduled start time of the first stream and a scheduled start time of a succeeding multicast stream;

receiving a request for the video content at a first time, the first time being after the scheduled start time, the request being the first request for the video content received by the network server after the scheduled start time; and transmitting the first stream over the network only after receiving the request.

**2.** The method of claim **1**, further comprising determining a point within the video content with respect to the beginning of the video content in which the transmission of the first stream begins.

**3.** The method of claim **2**, wherein the point within the video content is equal to the difference in time between the scheduled start time and the first time.

**4.** The method of claim **3**, wherein the electronic device joins the transmission of the first stream and displays the video content to the subscriber.

**5.** The method of claim **1**, further comprising:

retrieving the pushed segment from the electronic device; and

displaying the pushed segment to the subscriber before the transmission of the first stream over the network.

**6.** The method of claim **5**, further comprising providing a trickle server, wherein the plurality of multicast streams are delivered by the network server, and the pushed segment is pushed by the trickle server.

**7.** The method of claim **6**, wherein the plurality of multicast streams are delivered over the network at a first rate, and the pushed segment is pushed at a second rate.

**8.** The method of claim **7**, wherein the first rate is faster than the second rate.

**9.** The method of claim **5**, wherein the first stream has a first length, the pushed segment has a second length, the second length is shorter than the first length.

**10.** The method of claim **1**, wherein the electronic device is a set top box.

**11.** The method of claim **10**, wherein the set top box is a DVR.

**12.** The method of claim **1**, further comprising determining a trickle rate for pushing the segment of content to the electronic device.

**13.** A system for delivering video content to a subscriber, the system comprising:

a video server in communication with a video distribution network, the video server configured to deliver a plurality of multicast streams of video content over the video distribution network; and

an electronic device in communication with the video distribution network, the electronic device configured to communicate requests for video content to the video server, wherein the video server is configured to deliver each of the plurality of multicast streams over the video distribution network only after a request for the video content has been received; and

a trickle server in communication with the video distribution network, the trickle server configured to push video content to the electronic device during an inter-content gap, the pushed segment of video content having a length that is less than a total length of the one of the plurality of multi-cast streams and at least equal to and dependent upon a stagger interval between a scheduled start time of a multicast stream and a scheduled start time of a succeeding multicast stream.

**14.** The system of claim **13**, wherein the video server is configured to determine a point within the video content with respect to the beginning of the video content where the transmission of one of the plurality of multicast streams is to begin.

**15.** The system of claim **14**, wherein the electronic device is configured to join the transmission of one of the plurality of multicast streams and display the video content to the subscriber.

**16.** The system of claim **13**, further comprising:

a processor in communication with the trickle server and the video server, the processor configured to determine parameters for pushing a segment of the video content to the electronic device.

**17.** The system of claim **16**, wherein the electronic device is configured to join the transmission of one of the plurality of

**11**

multicast streams and display the video content to the subscriber, the electronic device is configured to retrieve and display the pushed segment to the subscriber before joining the transmission.

**18.** The system of claim **13**, wherein the electronic device is a set top box. 5

**19.** The system of claim **18**, wherein the set top box is a DVR.

**20.** The system of claim **13**, wherein the trickle server is configured to determine a trickle rate for pushing the segment of content to the electronic device. 10

\* \* \* \* \*

**12**